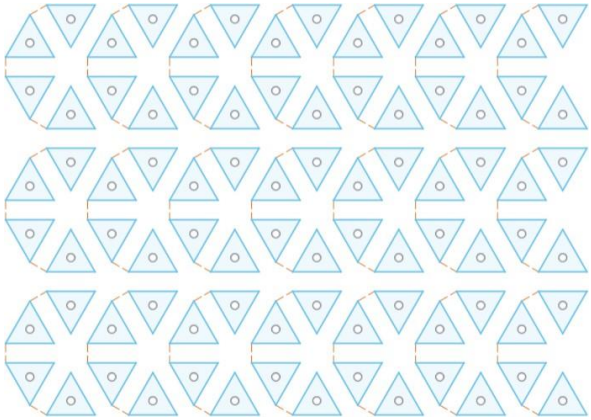
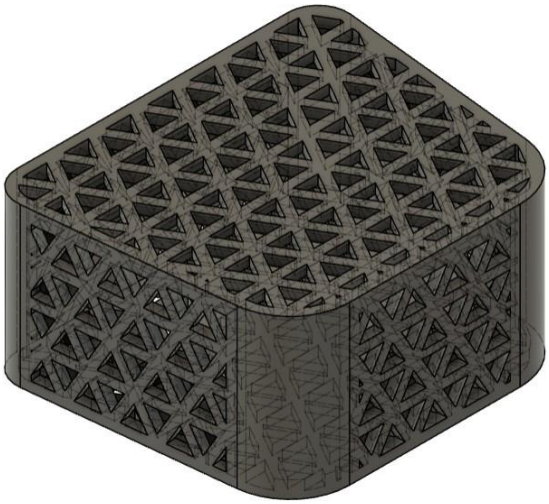
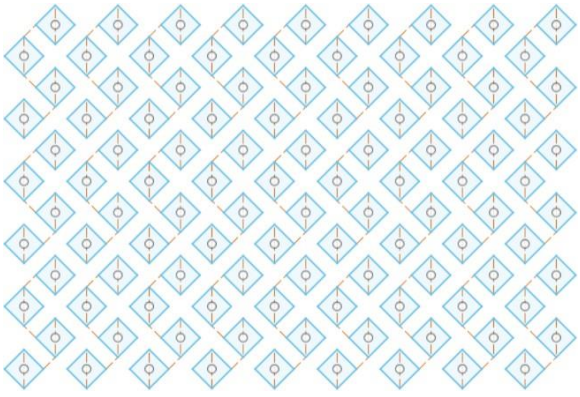
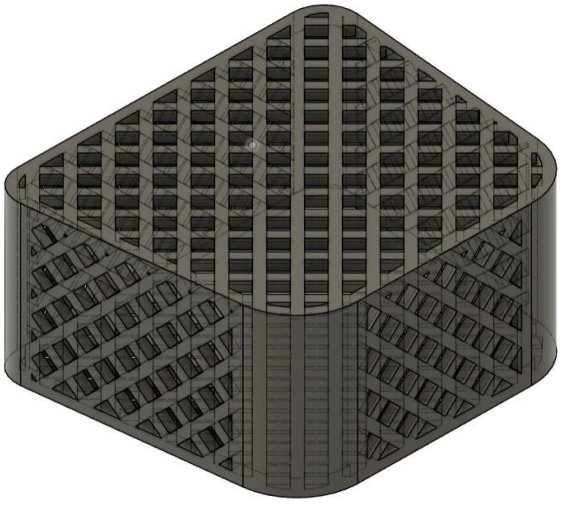
Supplementary: Spinal Fusion Cage Design

Table S1: Includes the designs for the main spinal fusion cages being tested in this research project. The left side of the table shows the tiling patterns, which were created in the sketch mode of the software Fusion 360, and were applied to the base geometry of a spinal fusion cage. The resulting figures following the application of the sketches onto the base geometry are depicted on the right side of the table which were created in Fusion 360's 3D modeling software.

Table 1: Tiling Design and Application to Spinal Fusion Cage

Triangular Tiling	**Triangular Tiling on Surface of Spinal Fusion Cage**
	
Diamond Tiling	**Diamond Tiling on Surface of Spinal Fusion Cage**
	

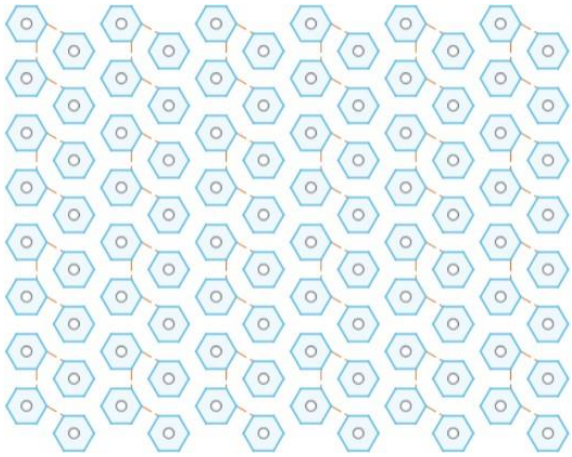
Hexagonal Tiling	Hexagonal Tiling on Surface of Spinal Fusion Cage
	

Table S2: Includes the dimensions for the spinal fusion cage geometries that were tested in the simulation. The base dimensions were created based upon a study conducted by Jain et al [28]. The dimensions for each of the tiling dimension designs were based upon the following equation in which the fusion cage geometry for the triangular tiling design was divided into an adequate number, and the other geometric dimensions were then modeled to cover the same areain order to provide comparable results from the simulation tests.

$$\frac{\sqrt{3}}{4} s_1^2 = s_2^2 = 3\frac{\sqrt{3}}{2} s_3^2$$

s_1=side length of triangle s_2=side length of diamond
s_3=side length of hexagon

Table 2: Spinal Fusion Cage Design Dimensions			
Base Spinal Fusion Cage Dimensions		**Tiling Design Dimensions**	
Base 1 Length	17.000 mm	**Triangular Tiling Design**	
Base 2 Length	14.000 mm	Side Length	1.250 mm
Base 1 Angles	84.000 degrees	Spacing Distance	0.500 mm
Base 2 Angles	96.000 degrees	**Diamond Tiling Design**	
Base 1 Filet Length	1.500 mm	Side Length	0.823 mm
Base 2 Filet Length	3.000 mm	Spacing Distance	0.500 mm
Leg 1 Length	14.350 mm	**Hexagonal Tiling Design**	
Leg 2 Length	14.350 mm	Side Length	0.510 mm
Height	8.000 mm	Spacing Distance	0.500 mm

Finite Element Analysis Parameters

Table S3: Includes the simulation parameters that were utilized in order to place each spinal fusion cage design under an axial compressive strength test. Each design was placed under separate simulation projects within SimScale; however, the parameters were maintained throughout each iteration in order to maintain the comparability of results.

Table 1: Simulation Parameters (Axial Compression Testing) Static Linear Analysis	
Contacts	
Bonded 1	
Position Tolerance	Off
Master Assignment	Bottom Face of Top Plate
Slave Assignment	Top Face of Fusion Cage
Bonded 2	
Position Tolerance	Off
Master Assignment	Top Face of Bottom Plate
Slave Assignment	Bottom Face of Fusion Cage
Connectors	
None	
Element Technology	
Definition	Automatic
Model	
Gravity Magnitude	0 m/s^2
Gravity Direction	0m in x,y, and z directions
Materials	
Titanium	
Material Behavior	Linear Elastic
Direction Dependency	Isotropic
(E) Young's Modulus	1.05e+11 Pa

(v) Poisson's Ratio	0.34
(p) Density	4500 kg/m^3
Assigned Volumes	Top Plate, Bottom Plate, and Spinal Fusion Cage
Boundary Conditions	
Fixed Value	
Displacement	0 m in x, 0 m in y, -4*t m in z
Assigned Faces	Bottom Face of Top Plate
Fixed Support	
Assigned Volumes	Bottom Plate
Numerics	
Solver	MUMPS
Precision Singularity Detection	8
Stop If Singular	True
Matrix Type	Automatic Detection
Memory for Pivoting (%)	20
Linear System Relative Residual	1e-5
Preprocessing	True
Renumbering Method	SCOTCH
Post Processing	Active
Distributed Matrix Storage	True
Memory Management	Automatic
Simulation Control	
Pseudo Time Stepping	Stepping List
Simulation Intervals	1s
Time Step Length	0.1s
Processors	
Number of Processors	Automatic (max 16)
Maximum Runtime	3600s

Result Control	
Solution Fields	Displacement, Cauchy Stress, Von Mises Stress, Total Strain
Area Calculation	None
Volume Calculation	
Average 1	
Volume Calculation	Average
Field Selection	Displacement
Component Selection	All
Assigned Volumes	Spinal Fusion Cage
Average 2	
Volume Calculation	Average
Field Selection	Stress
Stress Type	Von Mises
Assigned Volumes	Spinal Fusion Cage
Point Data	None
Mesh	
Algorithm	Standard
Sizing	Automatic
Fineness	5
Number of Processors	Automatic (max 16)
Maximum Meshing Runtime	1.8e+4 s
Small Feature Suppression	1.41e-4 m
Gap Refinement Factor	0
Global Graduation Rate	1.22

Table S4: Includes the simulation parameters which were utilized in order to place each spinal fusion cage design under an anterior compressive strength test. Each design was placedunder separate simulation projects within SimScale; however, the parameters were maintainedthroughout each iteration in order to maintain comparability of results.

Table 2: Simulation Parameters (Anterior Compression Testing) Static Linear Analysis	
Contacts	
Bonded 1	
Position Tolerance	Off
Master Assignment	Bottom Face of Top Plate
Slave Assignment	Top Face of Fusion Cage
Bonded 2	
Position Tolerance	Off
Master Assignment	Top Face of Bottom Plate
Slave Assignment	Bottom Face of Fusion Cage
Connectors	
None	
Element Technology	
Definition	Automatic
Model	
Gravity Magnitude	0 m/s^2
Gravity Direction	0m in x,y, and z directions
Materials	
Titanium	
Material Behavior	Linear Elastic
Direction Dependency	Isotropic
(E) Young's Modulus	1.05e+11 Pa
(v) Poisson's Ratio	0.34
(p) Density	4500 kg/m^3

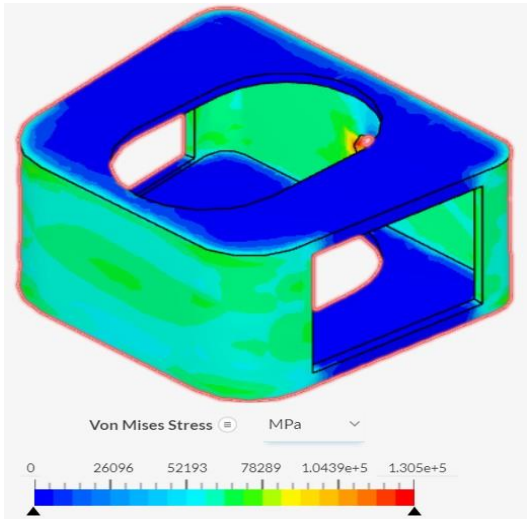
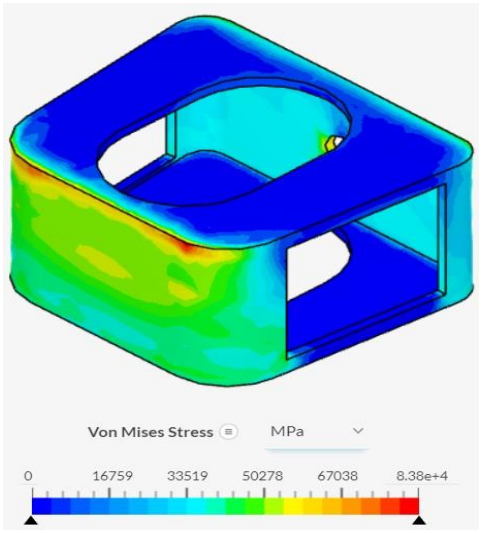
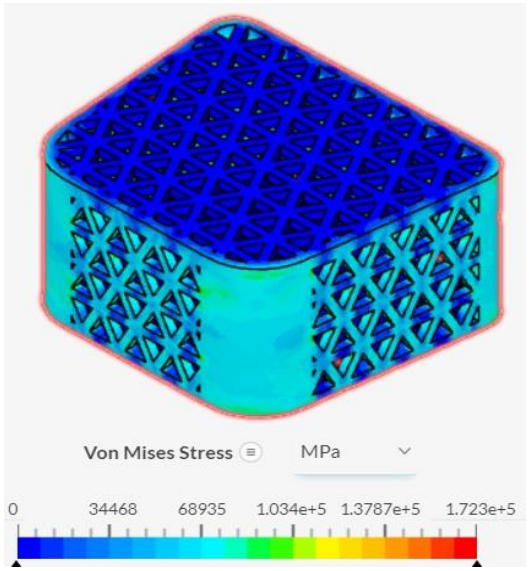
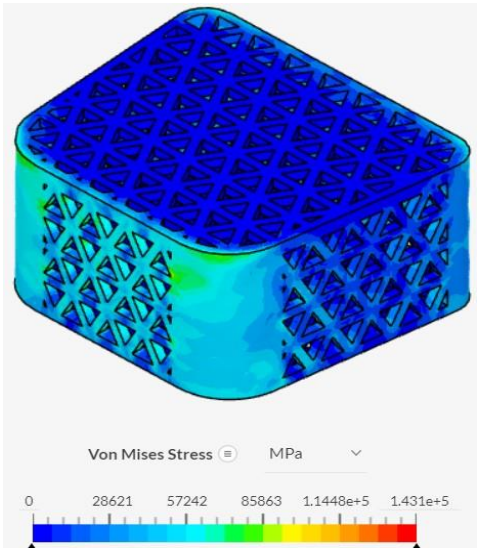
Assigned Volumes	Top Plate, Bottom Plate, and Spinal Fusion Cage
Boundary Conditions	
Fixed Value	
Displacement	0 m in x, 0 m in y, -4*t m in z
Assigned Faces	Front Face of Top Plate
Fixed Value	
Displacement	0 m in x, 0 m in y, 2*t m in z
Assigned Faces	Back Face of Top Plate
Fixed Support	
Assigned Volumes	Bottom Plate
Numerics	
Solver	MUMPS
Precision Singularity Detection	8
Stop If Singular	True
Matrix Type	Automatic Detection
Memory for Pivoting (%)	20
Linear System Relative Residual	1e-5
Preprocessing	True
Renumbering Method	SCOTCH
Post Processing	Active
Distributed Matrix Storage	True
Memory Management	Automatic
Simulation Control	
Pseudo Time Stepping	Stepping List
Simulation Intervals	1s
Time Step Length	0.1s
Processors	
Number of Processors	Automatic (max 16)

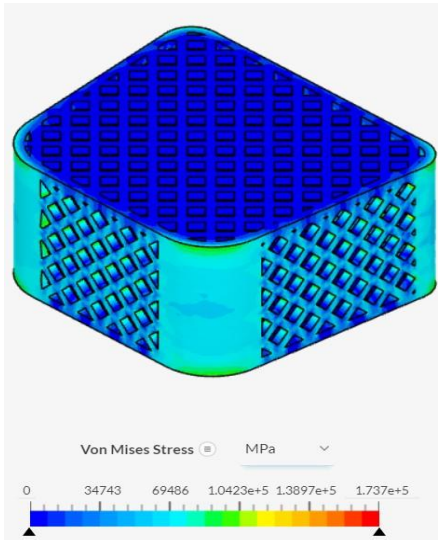
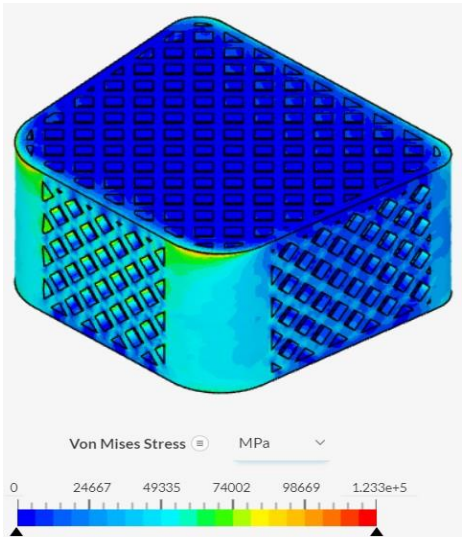
Maximum Runtime	3600s
Result Control	
Solution Fields	Displacement, Cauchy Stress, Von Mises Stress, Total Strain
Area Calculation	None
Volume Calculation	
Average 1	
Volume Calculation	Average
Field Selection	Displacement
Component Selection	All
Assigned Volumes	Spinal Fusion Cage
Average 2	
Volume Calculation	Average
Field Selection	Stress
Stress Type	Von Mises
Assigned Volumes	Spinal Fusion Cage
Point Data	None
Mesh	
Algorithm	Standard
Sizing	Automatic
Fineness	5
Number of Processors	Automatic (max 16)
Maximum Meshing Runtime	1.8e+4 s
Small Feature Suppression	1.41e-4 m
Gap Refinement Factor	0
Global Graduation Rate	1.22

Solution Fields

Table S5: Includes the solution fields which were collected following each simulation run in SimScale. It displays the von Mises stress distribution in MPa across each model through variation in coloring. Blue or cooler coloring indicates a lower value of von Mises stress while ared or warmer color indicates a higher von Mises stress value. Displacement field values were disabled to make the resulting solution fields more comprehensible.

Table 1: Solution Fields of Each Spinal Fusion Cage Design

Base Design under Axial Compression	**Base Design under Anterior Compression**
	
Triangular Tiling Design under Axial Compression	**Triangular Tiling Design under Axial Compression**
	

Diamond Tiling Design under Axial Compression	Diamond Tiling Design under Axial Compression
	
Hexagonal Tiling Design under Axial Compression	**Hexagonal Tiling Design under Axial Compression**